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A Preliminary Study of Applying Micro Waterjet

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ABSTRACT

This paper present a preliminary study of using a micro water jet as an environment friendly, cutting tool for sheet metal based rapid prototyping. Water jet have been used for sintering, solidifying and cutting materials to form a physical object layer by layer, but their high costs have motivated researchers to find for other less expensive technology or process as an alternative method. Basic introduction process of the micro water jet. Four different types of material sheets: metal, non metal, nature material, Polypropylene, Polyvinylchloride, natural rubber, have been found on their cut quality, surface finish and on the possibility of being implemented in this method. The results have shown that water jet process offers better cut quality as well as more environmentally friendly than the other processes. There are no's of area where the micro water jet process is used. Advantages of the water jet process to overcome the water jet process. Application of the water jet process are machining, general industries, electrical industries, medical technology, auto motive and motorsports, aerospace, watch making, etc. The future scopes for research in this process are Development of new cutting devices, cutting processes, Material tests, Process development and prototyping.

Keywords: Waterjet cutting, Rapid prototyping, Micro water jet, Metal cutting, micro machining process.

1. INTRODUCTION

Rapid prototyping is a technology that allows a physical object to be fabricated rapidly and directly from its 3D CAD model with little need for human intervention. Since it was initiated in the early 1980s, several rapid prototyping systems have been developed throughout these three decades and many of them are commercially available in the market, including Stereo lithography Apparatus (SLA), Selective Laser Sintering (SLS), Laminated Object Manufacturing (LOM), Fused Deposition Modeling (FDM), Solid Ground Curing (SGC), 3D Printing (3DP) and etc. Even though their techniques may vary, but they all are derived from the same basic principle, which is material is deposited and bonded with a previous layer to form a 3D physical object layer by layer.

Besides being classified according to three initial states of materials which are liquid, solid and powder, RP techniques can also be classified into five different layer forming processes: curing process, sintering process, dispensing process, binding process and sheet cutting process in (Upcraft and Fletcher 2003). Among these five categories, laser has played an important role in curing, sintering and sheet cutting processes. Rapid prototyping systems involving laser technology, however, are costly for investing, operating and maintaining. Among laser-based rapid prototyping systems, LOM is considered to be a less expensive technique because the cost of sheet material (e.g., paper sheet) is relatively lower than other kinds of materials in (Park et al. 2000; Cooper 2001; Upcraft and Fletcher 2003). Soft materials, such as paper and polymer sheet, are normally used in LOM which produces prototypes that can yield the physical and some functional satisfactions in (Park et al. 2000; Mahesh et al. 2004). However, the cost ratio of the laser to the overall system of typical sheet-based RP is relatively greater than that of other prototyping techniques. This has led to research on improving existing techniques as well as developing new inexpensive sheet-based RP techniques.
This paper presents a preliminary study of applying a micro water jet as a cutting tool for a sheet-based rapid prototyping. Next section presents related works. The investigations of using micro water jet in rapid prototyping are presented in below. It covers the investigation of using micro to cut different types of material sheets and the construction demonstration with some figure concept on selected material.

Micro water jet cutting technology is no different from normal water jet cutting. Micro water jet cutting is a cold, the rmoneutral separation process (pure water jet and abrasive processes) that manufacturers use at the micro level. The differences lie in the size of the cutting head and, with abrasive processes, in the size of the mixing chamber for the garnet sand. Micro water jet cutting was developed by Walter Maurer and the Waterjet AG team. The method combines the advantages of laser cutting precision with those of water: There are no thermal stresses in the material, and the microstructure of the material and its material strength are maintained. The development of micro water jet cutting was driven by demand. The trend in precision-engineered components is towards miniaturization and the use of sophisticated materials. Mechatronics, measurement and control technology, aerospace, medical technology and the watch industry require more finely crafted components made of special materials or composites.

2. MICRO WATERJET IN RP PROCESS

Micro water jet cutting technology is no different from normal water jet cutting. Micro water jet cutting is a cold, the rmoneutral separation process (pure water jet and abrasive processes) that manufacturers use at the micro level. The differences lie in the size of the cutting head and, with abrasive processes, in the size of the mixing chamber for the garnet sand. Micro water jet cutting was developed by Walter Maurer and the Waterjet AG team. The method combines the advantages of laser cutting precision with those of water: There are no thermal stresses in the material, and the microstructure of the material and its material strength are maintained. The development of micro water jet cutting was driven by demand. The trend in precision-engineered components is towards miniaturization and the use of sophisticated materials. Mechatronics, measurement and control technology, aerospace, medical technology and the watch industry require more finely crafted components made of special materials or composites. The precision depends on the cutting process and machine guidance. Precise cutting was increased by a process analysis, so that the water jet is newly round and the application of the abrasive can be dosed more accurately.

Figure 10 Micro Waterjet Process

3. THE APPLICATION OF MICRO WATERJET PROCESS

The normal waterjet system uses very high pressure of 200 to 400 MPa for cutting which is very high and very expensive for cutting soft materials, typical material used in Rapid Prototyping process. Using lower cutting pressure, approximately 8-12% of typical cutting pressure of the commercial system, may be sufficient to supply accept result on some soft materials, the cost of pumping system can be decreased.

In order to use micro waterjet for profile cutting in Prototyping system, three main issues which are different sheet materials, cutting environments and prototyping method need analyzed. In this preliminary study are material selection and demonstration of prototype model creation.

Different Materials

METALS

Steel and steel alloy, Noble metals: Gold, Silver, Platinum, Titanium, Tantalum, Inconel, Chromium, Nickel, Carbide, Hardened steel, Cast iron materials

ALUMINUM / NON FERRUS METALS

Aluminum and aluminum alloy, Brass, Bronze, Copper and copper alloy, Aluminum cast materials

GLASS

Glass (un-tempered), VSG, Bullet proof glass, Mirror

PLASTICS

Thermoplastic, Curable, plastics, Elastomer, Graphite, Carbon, Plexiglas

MINERALS

Stone, Granite, Ceramic, Stoneware, Quartz, Precious stone

SOFT MATERIALS

Soft foam, Hard foam, Dam and insulate materials, Wood, Paper, Cardboard, Leather

OTHER MATERIALS

Sandwich materials, structured materials, Perforated sheets, Composites, Layer materials

4. Advantages of Water-Jet Cutting Techniques

- Able to cut materials from felt to hard alloys
- Fast prototype production
- Flexible production, ‘Just in time’ fabrication
- High cutting speeds
- High cutting accuracy
- High surface quality
- Optimal material usage
- Low cutting forces
- No thermal impact (load)
- No change in material structure

- Narrow kerf width
- Minor burr on the cutting edge

Laser Cutting

In the laser cutting process, a high energy infrared laser light focused beam cut material by vaporizing and melting its highly impact area, then the molten material from the resulting cut is removed. It is one of the most accurate and fastest method for cutting a variety of metals and non-metals. Through Laser cutters, we can cut 16 gauge stainless steel at speeds up to 400 IPM with accuracy 0.001".

Advantages

- Cuts a variety of metals and non metals
- Can produce part accuracies better than 0.002"
- Can cut thinner metals at over 300 IPM
- Can produce cut edge squareness < 1 degree
- Can cut hole diameters < 1/2 material thickness
- Produces narrower heat affected zone than plasma
- Can process thin and thick metals simultaneously

Disadvantages

- Significantly higher capital cost than plasma or waterjet
- Cutting metals reflective to the laser beam (such as aluminum) can be hazardous to the focusing lens
- Can cause micro fracturing on some materials, a detriment for some aerospace applications
- Variations in material quality for carbon steel plate as well as surface rust can affect cut results
- Produces heat affected zone
- High cost for cutting assist gas, can be more than $15 per hour
- Long learning curve for process
- Laser maintenance requires advanced knowledge
- Produces fumes from the cutting process

Plasma Cutting

In The plasma cutting process, electrical arc firstly creates a superheated gas plasma jet by controlling its conductive and ionized properties. This plasma gas is hot enough to easily cut through a variety of metals, with part accuracies more than 0.008". Plasma cutting systems are most often used when the tight tolerances of a laser cutter (and it's higher capital costs) are not required.

Advantages

- Cuts a wide variety of metals
- Can produce part accuracies better than 0.008"
- Can process 16 gauge mild steel at over 200 IPM and 1" thick mild steel at over 45 IPM
- Fairly quick learning curve for process
- Simple maintenance
- Can be less than one third the purchase price of a similar sized laser system

Disadvantages

- Not as accurate as laser or waterjet
- Not ideal for applications with high volume hole cutting
- Consumables in cutting head deteriorate with use, affecting cut quality and accuracy
- Requires cutting head component change to process different metals and different metal thicknesses
- Not as flexible as laser in simultaneous processing of thin and thick metals
- Edge quality on plasma cut stainless steel not as acceptable in some markets as laser or waterjet processed parts
- Can cause micro fracturing on some materials, a detriment for some aerospace applications
- Produces fumes from the cutting process

5. CONCLUSIONS

Micro water jet cutting was investigated in this preliminary study for the developing a new inexpensive sheet material based rapid prototyping technique. This basic study was determining the possibility and the micro manufacturing concept via sheet material finding and small implementation on simple prototyping. It promotes green micro manufacturing as both sheet material and binding agent are natural product. with the help of the micro water jet process we can easily make smallest part. We can create the complicated shape easily. with help this process we can perform the machining operation on the all types of material like metal, non metal, polymer, natural material etc. micro water jet process takes less time create small big any complicated shape easily.

In the micro water jet processes Future researches are:

1. Development of new cutting devices and cutting processes
2. Material tests
3. Process development and prototyping

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